

5 What is claimed is:

1. An apparatus for detection of any intruder passing through a protected volume, comprising:

10 a first means for generating and modulating electromagnetic wave energy;
a second means coupled to said first means for radiating said electromagnetic wave energy into said protected volume;

a third means co-located with said second means for collecting a portion of said
15 radiated electromagnetic energy;

a fourth means for reflecting, said fourth means capable of redirecting a portion of said electromagnetic wave energy from said second means toward an associated fifth means for reflecting, said fifth means capable of redirecting said
20 electromagnetic wave energy back along a same line of propagation to said fourth means and thus to said third means, thereby forming an electromagnetic beam comprising radiated and reflected electromagnetic wave energy and having two segments, a first segment between said fourth means and said fifth means, and a second segment between said fourth means and said third means;

25

5 a plurality of said fourth means and a plurality of said fifth positioned along a base and ends of said protected volume for forming a plurality of said electromagnetic beams, each said electromagnetic beam comprising said first and second segments with a sum of lengths of said first and second segments being unique;

10

a structure located at a proximal end of said protected volume and coupled to both said second means and said third means capable of supporting said second means and said third means at a position above said base of said protected volume for providing line-of-sight propagation of said electromagnetic
15 beams between said second means and said third means and each of said plurality of said fourth means;

said structure located at said proximal end of said protected volume also capable of being coupled to and supporting another set of said plurality of said
20 fifth means, thereby providing a terminal end of said plurality of said electromagnetic beams at a plurality of heights above said base of said protected volume at said proximal end;

a structure located at a distal end of said protected volume and coupled to and
25 supporting another set of said plurality of said fourth means at a plurality of heights above said base of said protected volume, thereby providing junctions

5 between said first and second segments of said plurality of said electromagnetic beams at said plurality of heights above said base of said protected volume at said distal end;

a signal processing means coupled to said third means and capable of
10 determining a range to objects irradiated by said radiated electromagnetic wave energy, said signal processing means monitors a presence of said electromagnetic beams associated with each said fourth means and associated said fifth means, and for detecting a physical presence of said intruder within said protected volume, and;

15 an alarm circuit coupled to said signal processing means for generating an alarm when at least one of said electromagnetic beams is interrupted.

2. An apparatus for detection of intruder passing through a protected volume,
20 comprising:

a transmitter for generating and modulating electromagnetic energy;

an antenna coupled to said transmitter for radiating said electromagnetic wave
25 energy into said protected volume;

5 a receiver coupled to said antenna for receiving a portion of said radiated electromagnetic energy;

a plane reflector capable of redirecting a portion of said radiated electromagnetic wave energy from said antenna toward an associated
10 retroreflector, said retroreflector capable of redirecting said electromagnetic wave energy back along a same line of propagation to said plane reflector and thus to said antenna, thereby forming an electromagnetic beam comprising radiated and reflected electromagnetic wave energy and having two segments, a first segment between said plane reflector and said retroreflector, and a second
15 segment between said plane reflector and said antenna;

a plurality of said plane reflectors and said associated retroreflectors positioned at a plurality of locations along a base and ends of said protected volume capable of forming a plurality of said electromagnetic beams each having said
20 first and second segments, a sum of said first and second segments for each said electromagnetic beam having a unique value;

a sensor structure located at a proximal end of said protected volume and coupled to said antenna for supporting said antenna at a position above said
25 base of said protected volume for providing line-of-sight propagation of said plurality of said electromagnetic beams between said antenna and each of said

5 plane reflectors, said sensor structure also coupled to and supporting another set of said plurality of said retroreflectors, thereby providing a terminal end of said plurality of said electromagnetic beams at a plurality of heights above said base of said protected volume at said proximal end, junctions between said first and second segments of said electromagnetic beams being provided by said
10 plurality of said plane reflectors positioned at said plurality of locations along said base of said protected volume;

a reflector structure located at a distal end of said protected volume and coupled to another set of said plurality of said plane reflectors for supporting said plane
15 reflectors at a plurality of heights above said base of said protected volume, thereby providing said junctions between said segments of said plurality of said electromagnetic beams at said plurality of heights above said base of said protected volume at said distal end, said terminal end of said electromagnetic beams being provided by said plurality of said retroreflectors positioned at said
20 plurality of locations along said base of said protected volume;

a signal processing circuit coupled to said receiver and capable of determining a range to objects irradiated by said radiated electromagnetic wave energy, said signal processing circuit monitors a presence of said plurality of said
25 electromagnetic beams formed by each said plane reflector and said associated

5 retroreflector for detecting a physical presence of said intruder within said
protected volume, and;

an alarm circuit coupled to said signal processing circuit for generation of an
alarm when at least one of said electromagnetic beams is partially or completely
10 interrupted.

3. An apparatus as claimed in claim 2, wherein said transmitter generates said
electromagnetic wave energy in a millimeter-wave region of an electromagnetic
spectrum;

15 and said receiver receives energy in said millimeter-wave region of said
electromagnetic spectrum.

4. An apparatus as claimed in claim 2, wherein said antenna comprises means
20 for radiating said electromagnetic wave energy into said protected volume and
minimizing radiation outside said protected volume.

5. An apparatus as claimed in claim 2, wherein said plurality of said plane
reflectors positioned at said plurality of locations along said base of said
25 protected volume and coupled to said reflector structure at said plurality of
heights above said base of said protected volume comprise reflectors capable of

5 redirecting substantially all incident electromagnetic wave energy from said
antenna toward locations of said associated retroreflectors.

6. An apparatus as claimed in claim 2, wherein said plurality of said
retroreflectors positioned at said plurality of locations along said base of said
10 protected volume and coupled to said sensor structure at said plurality of heights
above said base of said protected volume comprise retroreflectors capable of
returning substantially all incident electromagnetic wave energy along a path
opposite in direction but parallel to a path of said incident electromagnetic wave
energy.

15

7. An apparatus as claimed in claim 2, wherein each said electromagnetic beam
comprises a substantial portion of said electromagnetic wave energy incident
upon said plane reflector and returned by said retroreflector, and said signal
processing circuit and said alarm circuit responsive to high signal-to-noise ratio
20 energy in said electromagnetic beams to provide high probability of detection of
said intruder while providing low probability of false alarm.

8. An apparatus as claimed in claim 2, wherein said antenna is located at a
position sufficiently high above said base of said protected volume, and wherein
25 said plurality of said plane reflectors are located at positions along said base of
said protected volume and a portion of said plurality of said plane reflectors are

5 positioned in a vertical arrangement on said reflector structure, and wherein said plurality of said retroreflectors are located at positions along said base of said protected volume and a portion of said plurality of said retroreflectors are positioned in a vertical arrangement on said sensor structure to generate a sufficient number of said electromagnetic beams with beam-to-beam spacing
10 sufficiently small and upper beam height sufficiently high to preclude said intruder passing through said volume without detection.

9. A method of detecting an unauthorized intrusion, comprising:
generating and modulating electromagnetic wave energy;
15 radiating said electromagnetic wave energy into a plurality of sections along a protected region;
redirecting a portion of said radiated electromagnetic wave energy from at least one of said sections to another section of said protected region;
reflecting said redirected electromagnetic wave energy from said another
20 section back along a same line of propagation to said at least one of said sections from which said electromagnetic wave energy was redirected;
collecting said reflected electromagnetic wave energy from said at least one of said sections, thereby providing a terminal end for said portion of said electromagnetic wave energy; and
25 indicating an occurrence of an unauthorized intrusion upon interruption of said electromagnetic wave energy along any line of propagation.